NATIONAL BUREAU OF STANDARDS
Technical News Bulletin

CONTENTS

Cover: Peeling paint in older homes provides an open invitation to youngsters. While the lead-based paint is sweet tasting, it can cause nausea, brain damage, and even death. See page 73 for related article. (Photo courtesy of Ross Laboratories, Columbus, Ohio)

ELECTRON RECOMBINATION REACTIONS

Gamma rays, x rays, alpha particles, and high energy electrons cause ionization in materials through which they pass. Chemical reactions initiated by these ions are responsible for such effects as corrosion in nuclear reactors, the destruction of cancer cells, and the strengthening of plastics.

Scientists at the Bureau are studying the rates and mechanisms of the ionic reactions occurring in systems under high-energy electron irradiation. The NBS investigators, taking advantage of the fact that charge recombination is fast at high-radiation dose rates, have made the first accurate determination of the rate at which positive organic ions recombine with electrons and with negative ions in the gas phase at atmospheric pressures.

With support from the U.S. Atomic Energy Commission, R. E. Rebbert, S. G. Lias, and P. Ausloos of the NBS Physical Chemistry Division irradiated samples of neopentane and methane with a pulsed electron beam from the high-intensity, Marx electron generator at the NBS Center for Radiation Research. These compounds were chosen for study because each has a simplifying feature: The major ions formed in the system do not react with the parent compound itself. Therefore, in both cases, small amounts of foreign compounds were added to the system. These compounds react with the positive ions in the system at known rates to give specific product compounds. At the dose rates attained in the pulsed electron experiments, recombination of the ions by an electron is fast enough to compete with chemical

Information concerning basic ion reactions is being gathered to help in understanding more complex reactions. Here Richard E. Rebbert positions a small cylindrical reaction vessel in line with the large electron generator in rear.

reactions. Information about the rate of recombination can therefore be calculated based on the absolute yields of the chemical products formed under varying conditions of dose and additive concentration. This method involves chemically analyzing the final product formed in an elementary chemical reaction of a particular organic ion; thus the determined recombination rate constant is specific to that ion. Previously, in such recombination rate constant determinations, the chemical identities of the ions were not specifically known.

The major ion formed in the neopentane system during irradiation at atmospheric pressures is a tertiary butyl ion that does not react with neopentane. When isopentane or 2,3-dimethyl butane is added to the system, however, the t-butyl ion

will react with the additive to form isobutane as a final product. Analysis of the isobutane product allowed the determination of the rate constant for recombination of a t-butyl ion with an electron. As an added sidelight to this method, other reactive compounds were added to the neopentane to intercept the t-butyl ions. Starting from the previously determined rate constant for neutralization of this ion, it was found that the approach could be turned around to determine the rates of reaction of the t-butyl ion with other molecules.[1,2]

The chemical reactions of these ions are very fast, occurring at nearly every collision with the reactive added molecules. Because of this, most of the ions react during the radiation pulse, which has a du-

New NBS Director
Dr. Richard W. Roberts

Dr. Richard W. Roberts recently became the seventh Director of the Bureau. He came to NBS from his position as manager of Materials Science and Engineering at the General Electric Research and Development Center in Schenectady, N.Y.

Dr. Roberts succeeds Dr. Lewis M. Branscomb, who resigned early in 1972 to become Chief Scientist at International Business Machines Corp.

At the GE Research and Development Center, Dr. Roberts directed the activities of a staff of more than 250 scientists and engineers who have produced numerous advances in many different areas of technology. Major breakthroughs include the first gem-quality diamonds to be produced in the laboratory, significant advances in coal gasification research, unique cutting tools for machining space-age metals and alloys, new composite materials, a pollution-free coating technique, a revolutionary solid waste recycling process using special strains of bacteria, a wide variety of medical sensors and diagnostic devices, and the world's most powerful permanent magnets.

A native of Buffalo, N.Y., Dr. Roberts received his bachelor's degree with distinction in 1956 from the University of Rochester and his doctorate in physical chemistry in 1959 from Brown University. After serving as a National Academy of Science Postdoctoral Fellow at the National Bureau of Standards, he joined General Electric in 1960.

As a research scientist, Dr. Roberts gained international recognition for his studies of ultrahigh vacuum technology, the physical and chemical properties of atomically clean metal and semiconductor surfaces, chemical kinetics, and the lubrication of space-age metals. Among other achievements, he played a major role in the development of a new family of lubricants that make it possible to use titanium, stainless steel, and other "unlubricable" materials for the moving parts in machines of the future.

More than 70 technical publications have been written or coauthored by Dr. Roberts, he is coauthor of the book *Ultrahigh Vacuum and Its Applications*, and he holds two patents.

Dr. Roberts is a member of the American Chemical Society, the American Physical Society, the New York Academy of Sciences, the American Nuclear Society, the American Association for the Advancement of Science, and Phi Beta Kappa and Sigma Xi honorary societies. He is a senior member of the American Vacuum Society, a Fellow of the American Institute of Chemists, and associate editor of the *Annual Review of Materials Science*.
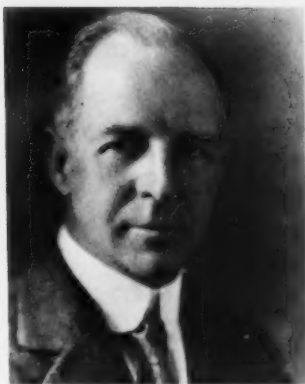
NBS DIRECTORS

Shown here are the previous NBS Directors and the years during which they held this position.

Dr. Samuel W. Stratton, 1901–1922

Dr. George K. Burgess, 1923–1932

Dr. Lyman J. Briggs, 1933–1945

Dr. Edward U. Condon, 1945–1951

Dr. Allen V. Astin, 1952–1969

Dr. Lewis M. Branscomb, 1969–1972

NEW OVEN CONSTRAINS CORROSIVE VAPORS

Vapors from such highly corrosive substances as molten aluminum and iron can be contained for spectroscopic investigation in a newly designed heat-pipe oven being developed at the Bureau. This new oven greatly expands the applicability of the original capillary wick type of heat-pipe oven developed in 1969 at NBS by Drs. C. Vidal and J. Cooper of the Boulder Laboratories. The new design, which utilizes centrifugal force instead of a wick to return the condensate, was developed and constructed by Dr. Thomas Lucatorto of the NBS Optical Physics Division, and Dr. Merrill Hessel of NBS Boulder.[1] The remodeled oven came in response to a request by Dr. Seth Shulman of the Naval Research Laboratories for a device to measure the photoionization cross section of atomic iron.

The new rotating oven is very similar to the earlier one except that the straight-walled tube with a mesh on the inner surface has been replaced by a tube with a double conical taper. This taper gives the middle portion of the tube, the evaporating section, a larger inside diameter than the ends, the condensing sections. Thus a rotation about the tube's longitudinal axis generates a force which causes any material in the condensing section to return to the evaporating section.

About 10 cm³ of the material to be studied is placed in the middle of the pipe. The system is then evacuated and refilled with a few torr of an inert gas. Heat, through the action of an rf heating coil, is applied to the central 5 centimeters of the tube. As the material evaporates from the heated region some of the vapor condenses in the slightly cooler adjacent regions. If enough heat is applied, the pressure of the vapor becomes equal to that of the buffer gas with the result that the evaporation and condensation of the material creates an almost isothermal zone. The length of the zone is proportional to the power input. The resultant mass motion of the vapor from the middle pumps the buffer gas into the ends of the pipe creating a central region of almost pure vapor contained between two plugs of almost pure buffer gas. (The buffer gas protects the windows at either end from corrosive attack by the vapor.) In the short zone (typically about equal to the tube diameter) between the vapor and the buffer gas is a region of sharp temperature falloff which marks the transition from the pure vapor to the pure buffer gas.

When the pipe rotates at a sufficient speed, the condensate is thrown against the inner wall of the tube and a component of force is generated toward the evaporating region. In the first model the angle of the taper was 2° and the average internal diameter 2 cm; the return force generated on the working fluid at 2,000 rpm was approximately 2 g. For dealing with materials that are very viscous at the desired operating temperature the return force can be increased by an order of magnitude or more by increasing the rotational speed, the angle, the taper, and the diameter of the tube.

The performance of the first model was tested with sodium (Na) and then with indium monoiodide (InI). Sodium was chosen for the initial test because of its low viscosity and well-known vapor pressure which is close to that of the InI. As expected, the rotating sodium heat pipe performed just like the conventional, wicked version. A rotational speed of about 600 rpm was adequate to maintain the return flow of the condensate.

Once this preliminary check had been performed, Hessel and Lucatorto used the pipe to study the band structure of the InI molecule. InI was heated in the pipe, and argon was used as the buffer gas. Unlike the results with Na, the InI was not fully liquified at all pressures and temperatures. At a temperature which corresponded to about 3 torr vapor pressure the InI appeared to be a slush mixture, and the rotational speed had to be increased to about 1,500 rpm to maintain the return flow.

The study of the structure of the InI molecule is typical of the use of the heat-pipe oven in spectroscopy. A high-pressure xenon arc was placed at one end of the rotating heat pipe and the molecular absorption spectra of electron transitions was photographed in the region of 3,700 − 4,100 Å on the NBS 10-meter Eagle spectrograph.

Hessel is continuing the development of the rotating pipe during his stay at the Boulder Laboratories while a visiting scientist from Fordham University. For the construction of the first pipe he used the conventional technique of cutting a taper on a lathe. This was very time consuming because he used long boring tools which cut very slowly. New pipes are being made by an hydraulic molding technique in which a cylindrical stainless steel tube is forced into a double conical mold by filling the tube under very high pressure. Hessel is also constructing a ceramic version which will be used to study the photoabsorption of iron vapor and other substances which are very reactive and require high temperatures. A collaborative venture with Shulman for measuring the photoionization cross section of atomic iron is also planned.
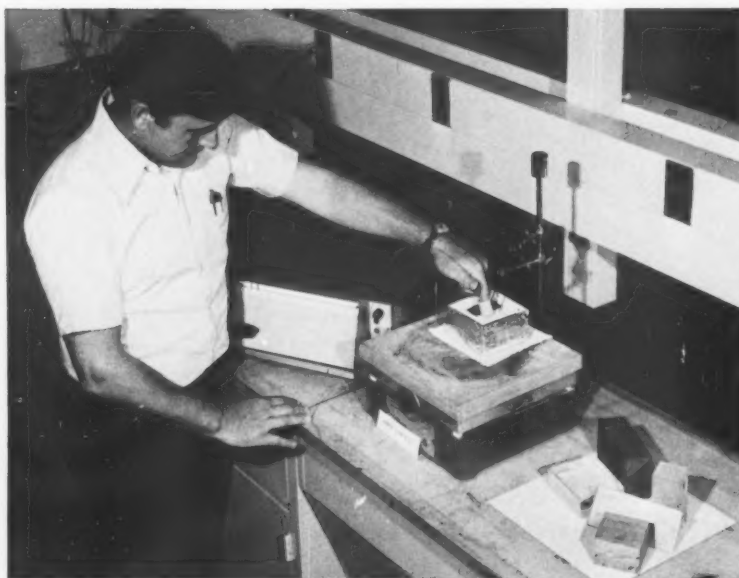
[1] Hessel, M. M., and Lucatorto, T. B., The rotating heat-pipe oven; a universal device for the containment of atomic and molecular vapors (to be published).
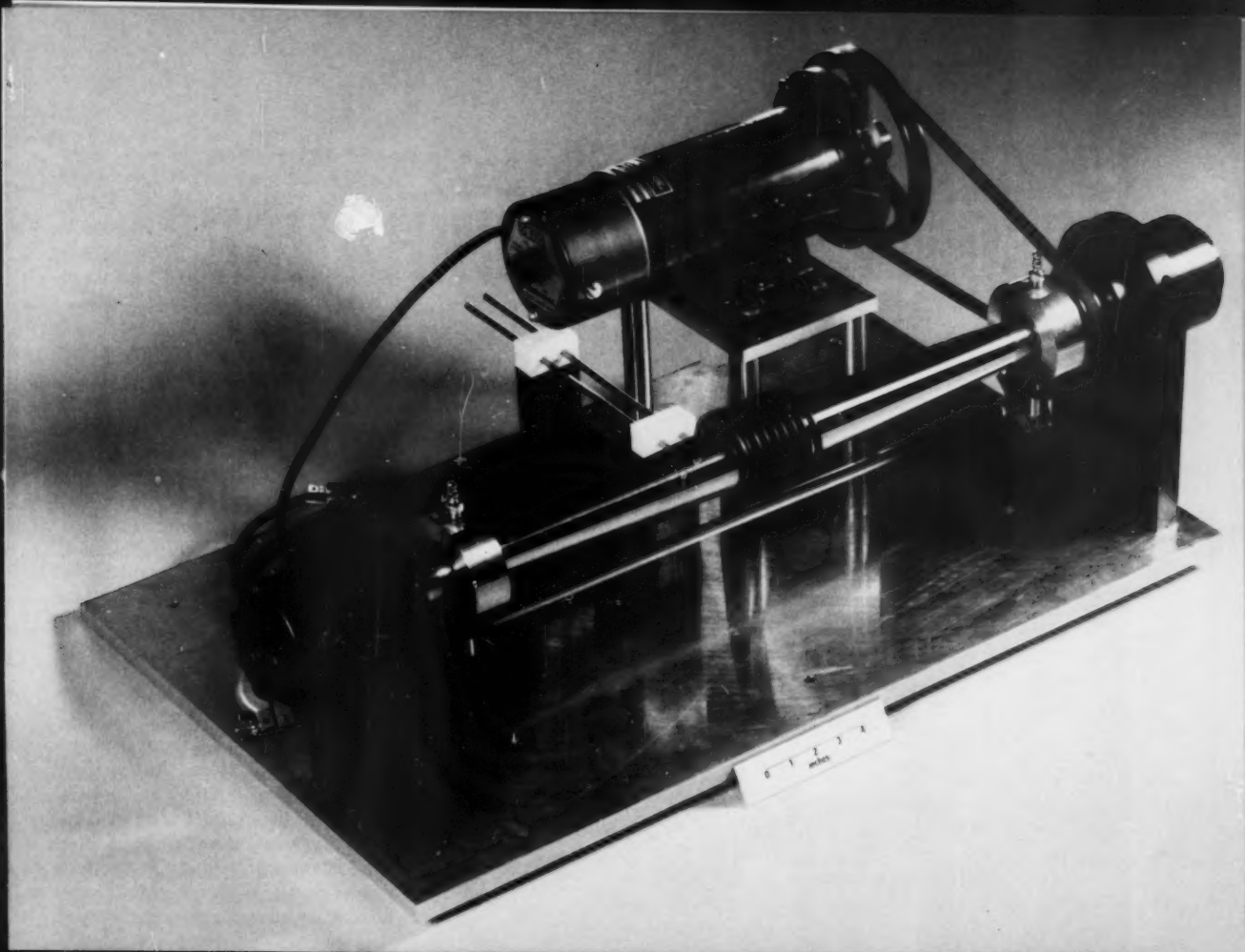
Above. This new version of the rotating heat-pipe oven uses centrifugal force to return the condensate to the central region. Below. Schematic of the rotating heat-pipe oven.

LOWER TEMPERATURES
RECOMMENDED FOR RANGES

James Huckeba participates in an experiment to determine the temperature at which contact with a particular surface becomes painful.

The front and sides of ranges can get very hot—hot enough to be the source of burns.

To reduce this common household danger, the Bureau has recently issued recommendations that could help range manufacturers design safer products. The recommendations resulted from a study sponsored by the Food and Drug Administration's Bureau of Product Safety, with cooperation from the gas and electric range industries.

As a result of NBS research, safe surface temperatures were determined for various materials used in making sides and handles of ranges. These temperatures are low enough so that any contact with the material's surface lasting 1 second or less will not cause skin to burn or blister. One second or less is the time required by most people to react to pain.

The Bureau of Product Safety has already incorporated the maximum temperature recommendations into a regulation governing sale of toys, such as toy electric stoves or popcorn makers that contain heating elements, lights, or motors. The temperature recommendations are now being reviewed by gas and electric range manufacturers for possible inclusion in their voluntary product standards.

How do people react to excessive temperatures? What constitutes "burning" one's skin? Do various materials, heated to the same temperature, feel equally hot? These are some of the basic questions that concerned Dr. Young-Chi Wu, principal investigator in the NBS study.

Dr. Wu said, "We know from experience, and from the medical literature, that people can respond to pain in less than 1 second. That is, it takes less than 1 second from the instant of touching a hot surface to feel pain and to pull away. Therefore, if we design range surfaces so that they will not get hot enough to cause skin to burn when exposed to their surfaces for 1 second, we will significantly reduce the danger."

"Burning of skin involves the death or severe disorder of living cells," Dr. Wu said. "The temperature at which cells will begin to die is about 111 °F (44 °C)."

NBS researchers noted that, other things being equal, the rate at which material will cause an object in contact with it to get hot—the "heat transfer rate"—will vary from one material to another. This means that the temperature safety limits for different materials used in stove surfaces will also vary.

Examples of materials often used in range walls and handles include: bare and painted metal, porcelain enamel, glass, and plastic. A procedure was developed to deter-

mine human responses to these materials at various temperature levels. Dr. Wu and two other NBS members, Sid Fischler and Jim Huckeba, volunteered to participate in the test.

Samples of materials were heated in an oven or on a hot plate. The samples were attached to instruments in such a way that their temperatures could be accurately measured over a period of time as they became hotter. The volunteers were asked to place a finger against the hot surface being tested, and to withdraw their finger when they felt pain. The instruments recorded the temperature of the material at the point when contact with its surface became painful.

The study and its results were discussed at a symposium held at NBS early in 1972. The gas and electric range industries, manufacturers associations, and testing laboratories were represented and expressed a very active interest in the development of better standards for ranges.

NBS researchers are now working to develop an instrument, for use by safety inspectors and range manufacturers, that will simplify the measurement of burn-producing temperatures on range surfaces. The instrument consists basically of a probe, or cylindrical device, that simulates a human finger. The probe is covered by a rubber material that will absorb heat at a rate similar to that of skin. When the probe is placed in contact with a heated surface, the temperature just below the surface of the rubber covering will be recorded. If this temperature reaches 111 °F it indicates that skin, in contact with the same surface for approximately 1 second or longer, would be subject to burning. Use of the instrument will make it possible to test the safety of a heated object quickly, and without having to know what material it is made from, or its surface temperature.

Electrical Engineering Units and Constants Card

Increased interest in the International System of units has prompted the production of a revised Electrical Engineering Units and Constants card as an aid for teachers, students, physicists, and electrical engineers concerned with design, specifications, and standards.

The wallet-size plastic card displays units and symbols on one side, physical constants and decimal prefixes are shown on the other.

The revised card was produced by G. F. Montgomery, Chief of Measurement Engineering, aided by a Bureau-wide committee. The card is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, or local U.S. Department of Commerce Field Offices, for 10 cents each, or $6.25 per 100. Use SD Catalog No. C13.10:368 when ordering, Stock Number 0303-01046.

Since 1965, about 75,000 of the original Electrical Engineering Units and Constants cards have been distributed by the Government Printing Office and more than 150,000 have been distributed by NBS.

Two similar cards are also available at the same price: Metric Conversion Card (Order SD Catalog No. C13.10:365); and General Physical Constants (Order SD Catalog No. C13.10:344).

PERFORMANCE STANDARDS FOR
X-RAY SYSTEMS

New standards are being developed for x-ray systems used in the detection and identification of weapons, explosives, and incendiary devices.

Bureau scientists are developing voluntary performance standards for the National Institute of Law Enforcement and Criminal Justice (NILECJ), the research arm of the Law Enforcement Assistance Administration of the U.S. Department of Justice. The new standards—under development by Charles N. Smith* of the NBS Applied Radiation Division in collaboration with Robert M. Mills of the NBS Law Enforcement Standards Laboratory (LESL)—will give potential users of x-ray systems a working description of the performance criteria that should be evaluated when purchasing x-ray equipment for weapons or bomb detection.

Using the same principles dentists use to x-ray teeth, law enforcement groups use x-ray systems to identify dangerous concealed objects. Time is important when searching baggage boarding airplanes or for detecting a bomb before it explodes. So x-ray systems used for criminal investigations need to be of exceptionally high performance and high operating speeds. These characteristics are desirable whether the images are produced on fast processing film or on a TV-monitored fluorescent screen.

X-ray systems under study are operated under two different sets of

*Present address: Atomic Energy Commission, Directorate of Licensing, F&M, Materials and Plant Protection Branch, Washington, D.C. 20545.

conditions. Used simply as a screening instrument, the system should be able to detect a potentially dangerous object or device and provide identification of the weapon or device. When used in a more detailed analysis, the x-ray system must define the components of a bomb that need to be deactivated.

SCREENING DEVICES

X-ray systems can be used by post offices, airports, and shipping docks to screen very large numbers of parcels for concealed guns, knives, bombs, incendiary devices—even narcotics.

Rapid analysis of a two dimensional x-ray image requires a skilled operator; one who can distinguish between the normal, harmless materials and those containing suspicious objects. For instance, it is difficult to distinguish between a normal battery operated radio and one in which a bomb has been incorporated.

While screening systems must produce an image of good enough quality to enable general classification of objects, it is *not* the job of the screening operator to be able to detail the intricate workings of a device; that is left for the discrete x-ray system.

X-ray systems used for screening are generally stationary and operated indoors to supply adequate images for the detection and the identification of weapons and other devices. Because many people are normally in close contact with the screening systems during operation, they must be protected against radiation.

BOMB COMPONENT DETECTION

As opposed to these stationary screening x-ray systems, another class of x-ray units is finding wide use among today's bomb disposal squads. These are portable x-ray systems used first to positively identify the bomb and then to determine the timing or firing mechanism and other critical internal parts in preparation for deactivating it. The discrete-item systems must be extremely sensitive so that every picture is sharp and complete in all details. These units must be light enough in weight to be carried by two men, operable under outdoor temperature extremes, and produce high quality images. Since these devices are not in continuous operation, and because they are normally used by bomb disposal experts working in evacuated areas, leakage radiation is generally higher due to lack of shielding, but is still within the limits established for radiation workers.

STANDARDS

The performance standards for discrete and screening devices will include sections on purpose, scope, definition of terms, requirements, and test procedures. While most of these are obvious, the requirements for a system's use include, for example, image quality, set-up and operating time, portability, leakage radiation, fire and shock hazards, and ruggedness. Although some of these criteria may be found in both standards, the quantitative levels vary significantly. The standards are *not* lists of instruments
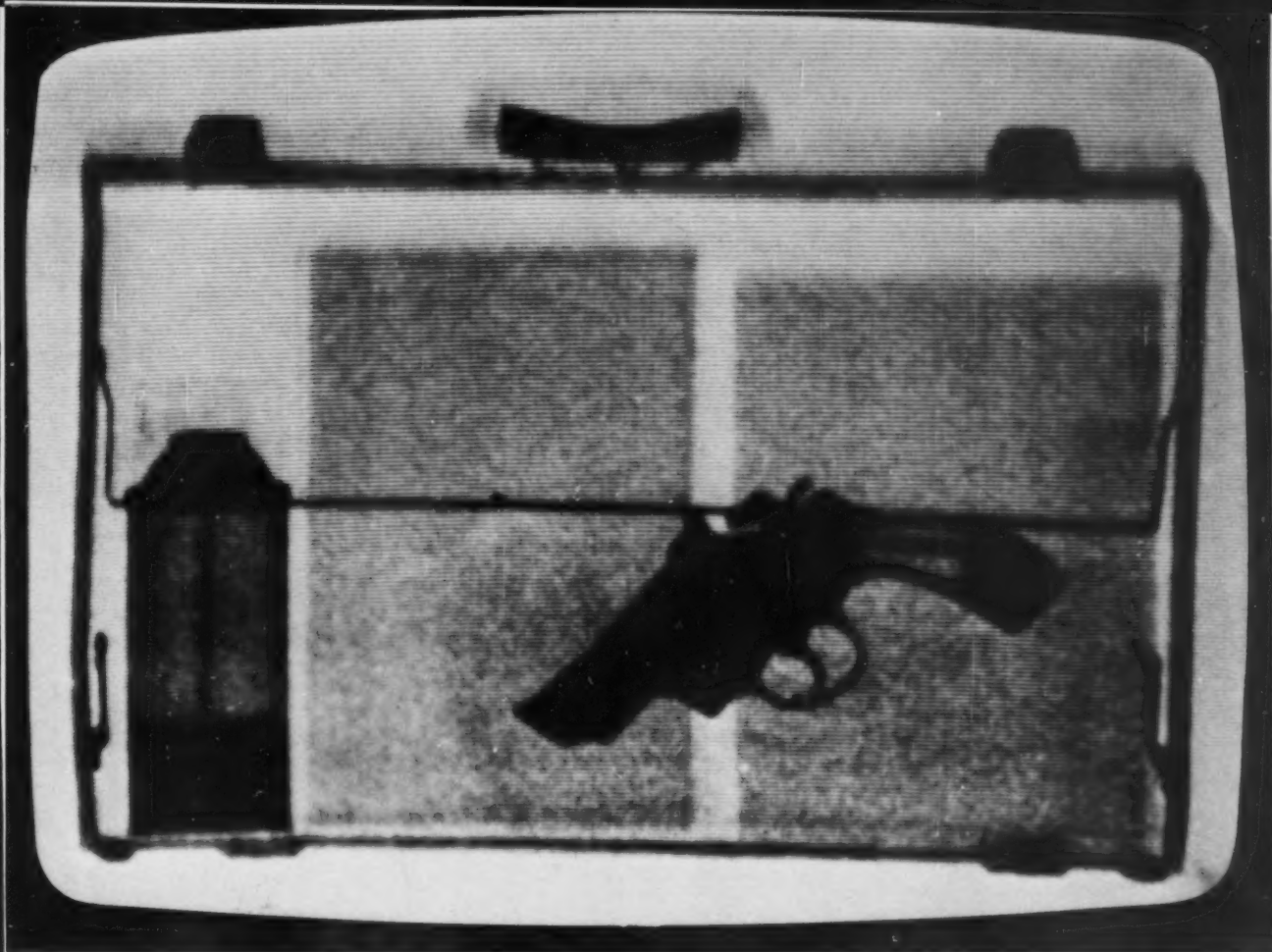
X-ray monitoring of luggage (top) can readily reveal hidden weapons. (Photo courtesy American Science and Engineering.)

proposed for particular uses, but are characteristics that, in general, should be evaluated with respect to both the user's needs and the potentials of the x-ray system in question. These standards should prove extremely valuable for manufacturers and for law enforcement groups that plan to purchase x-ray systems.

Upon final review and approval by NILECJ, the organization for which NBS-LESL is developing the standards, the "Standard on X-Ray Systems for Discrete Item Applications," will be promulgated as a NILECJ Standard. The next standard, "Standard on X-Ray Systems for Mass Screening Operations," will soon follow.
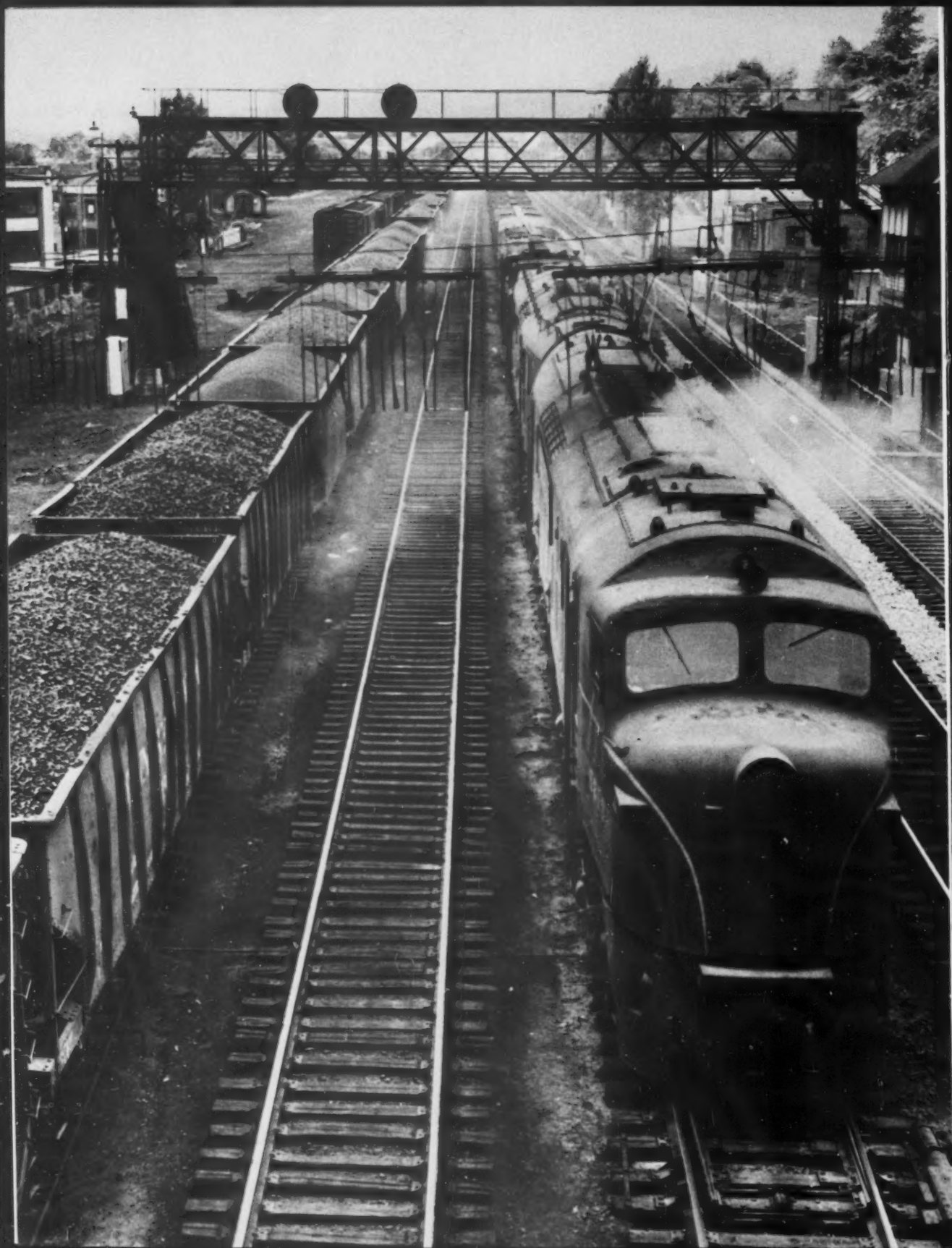
NBS AIDS
U.S. RAILROAD SYSTEM

A computer system that can help improve the management of the Nation's freight flow — nearly 3 billion tons each year — has been developed by the Bureau for the Department of Transportation (DOT).

The Bureau's Technical Analysis Division designed and programmed a package of computer programs which automatically computes the shortest rail routes (Short-Line Mile Distances) over which carload traffic can be moved without transfer of the shipment. The outputs from this system are used by DOT, ICC, the Railroad Industry, and the Research Community for setting freight rates, proposing regulatory legislation, and making economic and cost analyses. The computer programs and data files are public use items and are available from DOT.

The new computer system can store updated data when new freight stations are added or old ones phased out of the railroad network. The computer programs, programmers' documentation manual, and a report describing the project's background and operation have been published by DOT.[1,2]

A part of the nation's annual 3-billion freight tons in motion. NBS has developed a set of computer programs to calculate the shortest routes over which carload traffic can be moved without transfer of the shipment.

WHAT NBS ACCOMPLISHED

The U.S. railroad network, updated through 1969, consists of approximately 9,000 junctions (i.e., the switching intersections on the railroad lines), approximately 20,000 track segments (i.e., the connecting media between pairs of junctions), and some 60,000 stations (i.e., the loading or unloading points for freight using this network as the starting point). TAD constructed the short-line distancing package and used it to "mile" the 1969 waybill* file.

Prior to 1967 essentially the same short-line distance data were available to the U.S. Congress, the railway industry and its associations, and government regulatory agencies. However, the system was never fully automated, and therefore information was sometimes inaccurate and outdated. NBS brought the data on the entire Continental U.S. rail network up to date as of the year 1969 and developed an automated procedure for keeping the system permanently updated. For this task and others, TAD's Program Manager Martin Aronoff, and Project Leader Robert Ramsburg, had cooperation and assistance from DOT's Thomas C.

*A waybill, a document prepared by a railroad company transporting a shipment of goods, contains such information as the nature of the shipment, the name of its consignor and consignee, its origin, route, and the charges paid. It serves as a means of identification, a guide for routing, and a basis for freight accounting and many other shipping statistics.

Muranyi, ICC's Edward Margolin, Robert G. Rhodes, and James George, and the Association of American Railroad's Peter L. Conway, Jr.

After the data on the U.S. rail network was updated, TAD developed a package of sophisticated computer software to compute minimum routes. The short-line distances calculated by the package were validated by comparing each short-line distance with a straight-line distance (city-to-city and/or station-to-station). When a particular short-line distance deviated beyond allowable errors limits, it was discarded, and other means were used to bring that short-line distance into required agreement with the straight-line distance standard. The DOT intends to apply its experience gained with computerized short-line distancing to allied problems in the Nation's rail freight transportation system. Already the many requests from the American Association of Railroads and various individual railroads attest to the acceptance and importance of this valuable work.

[1] Ramsburg, R. E., and Aronoff, M. J., Calculation of Minimum Distances for the United States Railroad System by Digital Computer, Report No. 1 to Department of Transportation under Interagency Agreement, DOT-AS-10020.

[2] Ramsburg, R. E., and Batten, D. R., Programmer's Documentation of the Short-Line Mileage Programs for the United States Railroad Network, Report No. 2 to Department of Transportation under Interagency Agreement, DOT-AS-10020.

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

PAPERS IN FOURTH ISSUE OF JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA AVAILABLE

Volume 1, No. 4, of the new quarterly, *Journal of Physical and Chemical Reference Data*, has been published by the American Chemical Society and the American Institute of Physics. The Journal contains the major output of the National Standard Reference Data System. This issue also includes a property and author index to all papers and abstracts published in the four 1972 issues of the *Journal of Physical and Chemical Reference Data*. Abstracts of the critical compilations and reviews included in the fourth issue are given below.

MICROWAVE SPECTRA OF MOLECULES OF ASTROPHYSICAL INTEREST. I. FORMALDEHYDE, FORMAMIDE, AND THIOFORMALDEHYDE

D. R. Johnson, F. J. Lovas, and W. H. Kirchhoff

The available data on the microwave spectra of formaldehyde, formamide, and thioformaldehyde are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, centrifugal distortion parameters, dipole moments, hyperfine coupling constants, and structural parameters are tabulated. Observed rotational transitions are presented for the astronomically interesting isotopic forms of these molecules when available. Detailed centrifugal distortion calculations have been carried out for the most abundant isotopic forms of these molecules, namely, $H_2{}^{12}C^{16}O$, $H_2{}^{13}C^{16}O$, $^{14}NH_2{}^{12}CH^{16}O$, and $H_2{}^{12}C^{32}S$. Transitions have been predicted and tabulated for the frequency ranges

1 MHz to 300 GHz for $H_2{}^{12}C^{16}O$,
100 MHz to 300 GHz for $H_2{}^{13}C^{16}O$,
500 MHz to 180 GHz for
$^{14}NH_2{}^{12}CH^{16}O$, and
100 MHz to 300 GHz for $H_2{}^{12}C^{32}S$.

All predicted transitions include 95 percent confidence limits; measured transition error limits have been reproduced from the original literature. References are given for all data included.

THE SURFACE TENSION OF PURE LIQUID COMPOUNDS

J. J. Jasper

The surface tension tables presented herein are the result of a literature survey, evaluation, and compilation of data of some 2,200 pure liquid compounds, 226 of which were reported for a single temperature. These are arranged with related compounds in the increasing order of their molecular weights. As far as possible, the method of measurement, nature of atmosphere to which the liquid was exposed during measurements, and the estimated accuracy are given for each liquid. The tabulated values were calculated from the derived results of directly measured quantities reported in the literature of many countries from about 1874 to 1969. Preliminary plots of the experimentally measured quantities indicated that the surface tensions of the liquid compounds are linear functions of the temperature over the reported operational range. The principle of least squares was applied to experimental surface tension values to establish the regression curves and their equations. The constants of the equations (slope and intercept), together with the standard deviations are given for each compound. The selection factors establishing criteria of quality of surface tension data are discussed. These include (a) method of measurement, (b) purity of compound, (c) quality of apparatus and assembly, (d) experimental procedure (experimentation), (e) reliability of measurements (most probable values), (f) experience of investigator, and (g) availability of data. There are 274 references listed alphabetically.

OSMOTIC COEFFICIENTS AND MEAN ACTIVITY COEFFICIENTS OF UNI-UNIVALENT ELECTROLYTES IN WATER AT 25 °C

W. J. Hamer and Y. C. Wu

This paper gives values for the osmotic coefficients and mean activity coefficients of uni-univalent electrolytes in aqueous solutions at 25 °C. The values are expressed on the molality or weight basis. The data available in the literature have been corrected to the presently accepted scales of atomic weights (1969) and temperature (IPTS 1968) and, where necessary, to the absolute electrical units of 1969 and the fundamental constants of 1963. The selected values of osmotic coefficients and mean activity coefficients for individual electrolytes have been made internally consistent thermodynamically. In some cases, estimated values are given; in other cases, references only are given when the data are sparse or unsuited to critical evaluation. Values of the osmotic coefficients and mean activity coefficients of 79 compounds are given together with the standard deviation, variance, and normalized standard deviation of their fit to equations which express these quantities as functions of electrolyte concentration. Finally, literature references are given to data on 51 additional uni-univalent electrolytes.

THE VISCOSITY AND THERMAL CONDUCTIVITY COEFFICIENTS OF GASEOUS AND LIQUID FLUORINE

H. J. M. Hanley and R. Prydz

Tables of values for the viscosity and thermal conductivity of fluorine are presented in the range 70-300 K for pressures up to 200 atmospheres. Experimental results were reviewed but were judged to be unreliable. Accordingly, dilute gas values were determined from kinetic theory using the m-6-8 potential, and dense gas and liquid values were obtained from the modified Enskog theory. The critical point anomaly in the thermal conductivity coefficient is also discussed.

REPRINTS

Bound reprint copies of each of the papers appearing in the fourth issue are available for purchase from the American Chemical Society, 1155 16th Street NW., Washington, D.C. 20036. For the convenience of readers, ordering information on all 16 papers published in volume 1 is listed below:

1. Gaseous Diffusion Coefficients, T. R. Marrero and E. A. Mason, Vol. 1, No. 1, pp. 1-118 (1972) $6.

2. Selected Values of Critical Supersaturation for Nucleation of Liquids from the Vapor, G. M. Pound, Vol. 1, No. 1, pp. 119-134 (1972) $3.

3. Selected Values of Evaporation and Condensation Coefficients of Simple Substances, G. M. Pound, Vol. 1, No. 1, pp. 135-146 (1972) $3.

4. Atlas of the Observed Absorption Spectrum of Carbon Monoxide between 1060 and 1900 Å, S. G. Tilford and J. D. Simmons, Vol. 1, No. 1, pp. 147-188 (1972) $4.

5. Tables of Molecular Vibrational Frequencies, Part 5, T. Shimanouchi, Vol. 1, No. 1, pp. 189-216 (1972) $3.50.

6. Selected Values of Heats of Combustion and Heats of Formation of Organic Compounds Containing the Elements C, H, N, O, P, and S, E. S. Domalski, Vol. 1, No. 2, pp. 221-278 (1972) $4.50.

7. Thermal Conductivity of the Elements, C. Y. Ho, R. W. Powell, and P. E. Liley, Vol. 1, No. 2, pp. 279-422 (1972) $7.

8. The Spectrum of Molecular Oxygen, P. H. Krupenie, Vol. 1, No. 2, pp. 423-534 (1972) $6.

9. A Critical Review of the Gas-Phase Reaction Kinetics of the Hydroxyl Radical, W. E. Wilson, Jr., Vol. 1, No. 2, pp. 535-574 (1972) $4.

10. Molten Salts: Volume 3, Nitrates, Nitrites, and Mixtures, Electrical Conductance, Density, Viscosity, and Surface Tension Data, G. J. Janz, U. Krebs, H. F. Siegenthaler, and R. P. T. Tomkins, Vol. 1, No. 3, pp. 581-746 (1972) $8.

11. High Temperature Properties and Decomposition of Inorganic Salts—Part 3, Nitrates and Nitrites, K. H. Stern, Vol. 1, No. 3, pp. 747-772 (1972) $3.50.

12. High-Pressure Calibration: A Critical Review, D. L. Decker, W. A. Bassett, L. Merrill, H. T. Hall, and J. D. Barnett, Vol. 1, No. 3, pp. 773-836 (1972) $4.50.

13. The Surface Tension of Pure Liquid Compounds, J. J. Jasper, Vol. 1, No. 4, pp. 841-1009 (1972) $8.

14. Microwave Spectra of Molecules of Astrophysical Interest I. Formaldehyde, Formamide, and Thioformaldehyde, D. R. Johnson, F. J. Lovas, and W. H. Kirchhoff, Vol. 1, No. 4, pp. 1011-1045 (1972) $4.

15. Osmotic Coefficients and Mean Activity Coefficients of Uniunivalent Electrolytes in Water at 25 °C, W. J. Hamer and Y. C. Wu, Vol. 1, No. 4, pp. 1047-1099 (1972) $4.50.

16. The Viscosity and Thermal Conductivity Coefficients of Gaseous and Liquid Fluorine, H. J. M. Hanley and R. Prydz, Vol. 1, No. 4, pp. 1101-1113 (1972) $3.

Single copies of the *Journal of Physical and Chemical Reference Data* are available from the American Chemical Society for $20. Make all checks payable to the American Chemical Society.

SUBSCRIPTION INFORMATION

Subscriptions to the *Journal of Physical and Chemical Reference Data* are available as follows: member,* domestic** $20, foreign $23; nonmember, domestic** $60, foreign $63.

COMBO: A GENERAL-PURPOSE PROGRAM

NBS Technical Note 700, *COMBO: A General-Purpose Program for Searching, Annotating, Encoding-Decoding and Reformatting Data Files* by Robert McClenon and Joseph Hilsenrath[1] (SD Catalog No. C13.46:700, 70 cents), is a program developed by the Data Systems Design Group of the Office of Standard Reference Data as part of its objective to prepare computer programs for handling the varied data file formats used by the data centers of the NSRDS.

COMBO is a FORTRAN program for searching magnetic tape files, generating reports, and reformatting files. The program is capable of reading separate card images from a file blocked in physical

*Member of ACS, AIP, or an affiliated society.
**Domestic rates apply to United States and possessions, Canada, and Mexico.

records and recognizing logical blocks marked by a fixed-field ID. Up to 99 different types of lines, each with its own format, can be recognized by examining a special code or label. The program can be instructed to search for the occurrence of each of certain character strings, using a different list for each type of line and two levels of Boolean logic. Lines can be broken into pieces, using either a fixed-field format or a single separator or flags to define the pieces, and the pieces can be rearranged, with labels or comments optionally inserted between them. Editing, in which specified strings are replaced by other strings, can also be performed. The program can accommodate a variable number of cards of each type per block. It was assembled from general-purpose subroutines of modular design and is substantially machine independent.

IUPAC NOMENCLATURE DOCUMENTS

In November 1972, the International Union of Pure and Applied Chemistry (IUPAC) issued four information bulletins on tentative nomenclature, symbols, units, and standards. Copies of all four bulletins listed below can be obtained from:

IUPAC Secretariat
Bank Court Chambers, 2/3 Pound Way
Cowley Centre, Oxford OX4 3YF,
United Kingdom

Comments and suggestions should be sent as follows:

Bulletin Number 26, Nomenclature, Symbols, Units and Their Usage in Spectrochemical Analysis—II: Terms and Symbols Related to Analytical Functions and Their Figures of Merit to:

Prof. H. Kaiser
Institut fur Spektrochemie und Angewandte Spektroskopie,
Postfach 778, Bunsen-Kirchhoff-Strasse 11,
D-4600, Dortmund, Germany

Bulletin Number 27, Nomenclature, Symbols, Units and Their Usage in Spectrochemical Analysis—III: Analytical Flame Spectroscopy and Associated Procedures to:

Prof. C. Th.J. Alkemade

Laboratorium voor Kernfysika en Vaste Stof der Rijksuniversiteit,
Sorbonnelaan, "De Uithof"
Utrecht, The Netherlands

Bulletin Number 28, Electrochemical Definitions and Symbols to:

Dr. R. Parsons
Department of Physical Chemistry
School of Chemistry
University of Bristol
Cantock's Close, Bristol BS8 1TS,
United Kingdom

Bulletin Number 29, Nomenclature of Regular Single-Strand Organic Polymers to:

Dr. K. L. Loening
Chemical Abstracts Service
The Ohio State University
Columbus, Ohio 43210
U.S.A.

or

Dr. L. C. Cross
The Chemical Society
Burlington House
Picadilly, London, W1V OBN
United Kingdom

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

ELECTRON *continued*

ration of 3 to 100 nanoseconds. The competition between chemical reaction and charge recombination is very sensitive to the intensity of the bombarding electron beam. Thus, the exact shape of the pulse as a function of time must be taken into account. A computer is used for this calculation.

If an electron scavenger—such as sulfur hexafluoride—is added to the system, the electrons will react to form negative ions. Charge recombination will then involve a negative ion. This slows the neutralization process by about an order of magnitude.

Electron-scavenged systems are of interest because the neutral species resulting from the neutralization process will not dissociate into smaller fragment radicals or molecules as often as those resulting from a more energetic encounter with an electron.

Comparison between final products formed in the presence or absence of sulfur hexafluoride allows the determination of the identities of the chemical products formed when a given ion undergoes charge recombination. Such experiments demonstrated, for instance, that when an ethyl ion recombines with an electron, acetylene is the major hydrocarbon product; recombination with a negative ion leads to the formation of ethylene. This

helps explain why scientists examining the effects of radiation on methane have often disagreed about the amounts of ethylene and acetylene formed in experiments in different laboratories.[3,4] It also helps to explain the formation of acetylene in electrical discharges in alkanes.

[1] Lias, S. G., Rebbert, R. E., and Ausloos, P., Gas phase pulse radiolysis of hydrocarbon mixtures; determination of the charge recombination rate coefficient and absolute rate constants of ion-molecule reaction of the t-butyl ion through a competitive kinetic method, J. Chem. Phys. **57**, No. 5, 2080-2086 (Sept. 1972).
[2] Rebbert, R. E., and Ausloos, P., Pulse radiolysis of neopentane in the gas phase, J. Res. Nat. Bur. Stand. (U.S.), **76A** (Phys. and Chem.), No. 4, 329-336 (July-Aug. 1972).
[3] Rebbert, R. E., and Ausloos, P., Radiolysis of methane. Formation of acetylene, J. Res. Nat. Bur. Stand. (U.S.) (to be published).
[4] Rebbert, R. E., Lias, S. G., and Ausloos, P., Pulse radiolysis of methane, J. Res. Nat. Bur. Stand. (U.S.) (to be published).

All You Will Need to Know About Metric

## (For Your Everyday Life)

10

Metric is based on Decimal system

The metric system is simple to learn. For use in your everyday life you will need to know only ten units. You will also need to get used to a few new temperatures. Of course, there are other units which most persons will not need to learn. There are even some metric units with which you are already familiar: those for time and electricity are the same as you use now.

BASIC UNITS

METER: a little longer than a yard (about 1.1 yards)
LITER: a little larger than a quart (about 1.06 quarts)
GRAM: about the weight of a paper clip

(comparative sizes are shown)
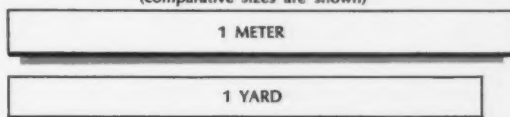
| 1 METER |
| 1 YARD |

25 DEGREES FAHRENHEIT

COMMON PREFIXES
(to be used with basic units)

Milli: one-thousandth (0.001)
Centi: one-hundredth (0.01)
Kilo: one-thousand times (1000)

For example:
1000 millimeters = 1 meter
100 centimeters = 1 meter
1000 meters = 1 kilometer

1 LITER   1 QUART

OTHER COMMONLY USED UNITS

Millimeter:	0.001 meter	diameter of paper clip wire
Centimeter:	0.01 meter	width of a paper clip (about 0.4 inch)
Kilometer:	1000 meters	somewhat further than ½ mile (about 0.6 mile)
Kilogram:	1000 grams	a little more than 2 pounds (about 2.2 pounds)
Milliliter:	0.001 liter	five of them make a teaspoon
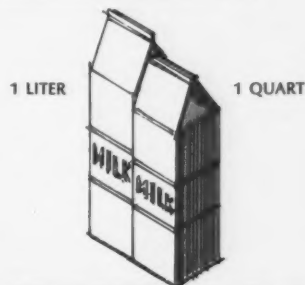
25 DEGREES CELSIUS

OTHER USEFUL UNITS

Hectare: about 2½ acres
Tonne: about one ton
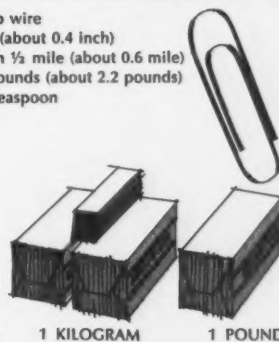
TEMPERATURE
degrees Celsius are used

°C	−40	−20	0	20	37	60	80	100
°F	−40	0	32	80	98.6	160		212
			water freezes		body temperature			water boils

1 KILOGRAM   1 POUND
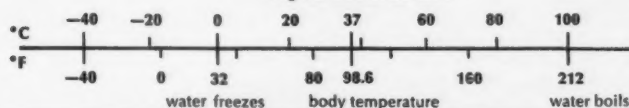
For more information, write to: Metric Information Office, National Bureau of Standards
Washington, D.C. 20234

NEW REFERENCE TABLES FOR LOW-TEMPERATURE THERMOCOUPLES AVAILABLE

Cryogenic technology, expanding rapidly over the past 20 years, requires precise temperature measurements between room temperature and absolute zero.

To meet this demand, the Bureau has evaluated some popular thermocouple alloys along with some relatively new alloys. These new alloys are especially suited for temperatures below 50 K.

The study, which revealed the variations to be expected between sample wires, also yielded new thermoelectric output tables for various combinations of wires.[1]

Liquid gases find application in such ever-expanding fields as steelmaking, medicine, food processing, energy production and transmission, and storage. Thermocouples provide a way to measure the low temperatures essential to liquid gas production and use. When dissimilar metals are joined across a temperature gradient, an electrical voltage which is proportional to the temperature difference results. However, the voltage generated also depends on a variety of other factors as well, such as the composition and homogeneity of the alloy, the history of mechanical strain of the wire, and the heat treatment of the wire. Variations are found between different manufacturers, between different production lots, between spools of one lot, and between various parts of a spool.

Some of the NBS research was aimed at determining the causes and ranges of these variations, so that users could estimate the need

for individual adjustments of their own thermocouple readings according to their own accuracy requirements. Another part of the study was devoted to generating new standard thermocouple tables of voltage versus temperature for many combinations of alloys. The tables are based on the IPTS-68 temperature scale for temperatures above 20 K and the NBS P2-20 scale for temperatures of 20 K and below.

The materials included in these tests were copper-nickel (type TN), nickel-chromium (type KP), and nickel-aluminum (type KN) alloys, copper, platinum, and silver alloyed with 28 atomic percent (28 at%) gold. These materials were tested for the variations due to manufacture and subsequent handling by "dip tests." These tests consist of dipping a continuous loop of the material or a thermocouple formed by joining widely separated lengths of wire into a cryogenic bath and measuring the voltage developed at the free ends of the loop. A perfectly homogenous material would develop no voltage under these conditions, while chemical and physical defects give rise to spurious thermoelectric voltages of various magnitudes. Well-prepared wire can have short-range (that is, occurring within a few meters of wire length) variations as small as 0.1 microvolt, whereas poorly controlled wires may show interlot variations as large as 100 microvolts.

The final stage of testing compared the emf of various thermocouple wire pairs to standard

thermometers in the cryogenic temperature range. From these tests, tables were generated showing the thermocouple output as a function of temperature with a zero K reference temperature. Tables and power series coefficients are given for thermocouple types T, E, K, Pt versus common materials, and Ag-28 at% Au versus common materials.

Silver-28 at% gold is used as a thermoelectric reference material at low temperatures because it is not as dependent on trace impurities as is platinum at temperatures below 50 K. This alloy is available from the Office of Standard Reference Materials, NBS Washington.[2]

For extremely low temperatures, below 25 K for example, gold alloyed with 0.02 or 0.07 at% iron is a useful thermocouple material. NBS data on these alloys versus copper, silver-0.37 at% gold, and nickel-chromium (type KP) are also available.[3]

[1] Sparks, L. L., Powell, R. L., and Hall, W. J., Reference Tables for Low Temperature Thermocouples, Nat. Bur. Stand. (U.S.), Monogr. 124 (June 1972).

[2] Sparks, L. L., and Hust, J. G., Thermoelectric Voltage of Silver — 28 at% Gold Thermocouple Wire, SRM 733, Versus Common Thermocouple Materials (Between Liquid Helium and Ice Fixed Points), Nat. Bur. Stand. (U.S.), Spec. Publ. 260-34 (1972).

[3] Sparks, L. L., and Powell, R. L., Low Temperature Thermocouples: KP, "normal" silver, and copper versus Au-0.02 at% Fe and Au-0.07 at% Fe, J. Res. Nat. Bur. Stand. (U.S.), 76A, No. 3 (May-June 1972).

Larry L. Sparks, of the NBS Cryogenics Division, records the output voltage of a thermocouple maintained at a calibrated temperature.
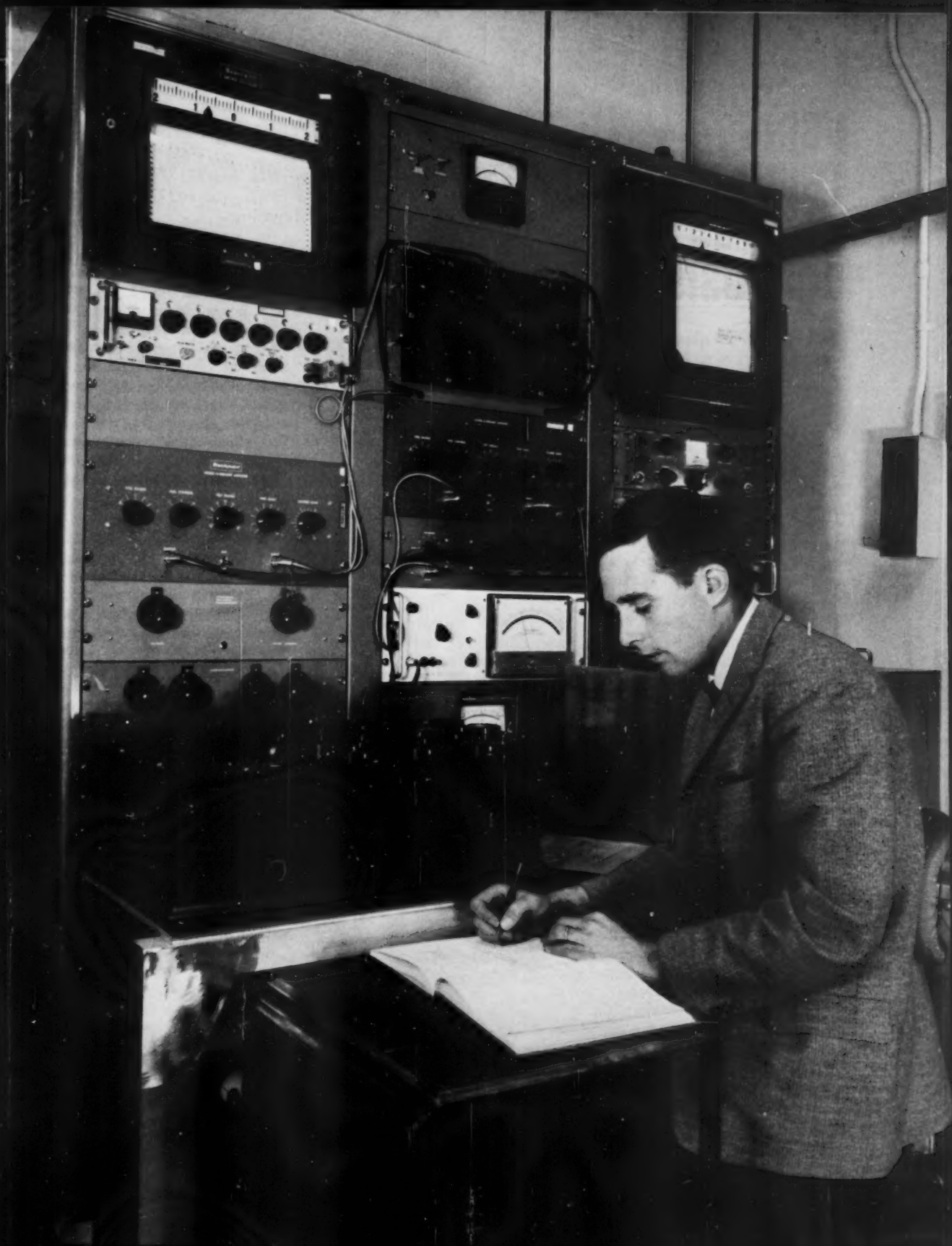
USING TRIBO-ELLIPSOMETRY TO STUDY CORROSION CRACKING

A technique developed at the Bureau could prove to be a valuable tool for predicting the susceptibility of an alloy to stress corrosion cracking. With this method, called tribo-ellipsometry, scientists can assess the effect of new and unknown environments on repassivation kinetics and metal dissolution kinetics.

With support from the Office of Naval Research, Drs. John R. Ambrose and Jerome Kruger of the NBS Institute for Materials Research developed a technique for abrading off the oxide film on metals and making rapid ellipsometric measurements of film regrowth (repassivation) while simultaneously measuring the current involved in the overall anodic process.[1] Knowing the extent of film growth, an estimate can be made of the amount of current consumed by metal dissolution. This is the only technique known that can be used to separate the total anodic current transient into two parts, that used in film growth and that used in metal dissolution.

Information gained in such studies will also contribute to the understanding of the mechanism of stress corrosion. The importance of the rate of repassivation to the mechanism of stress corrosion cracking has been indicated in previous studies. It is theorized that, under stress, the film existing on a metal fractures and, unless its repair is sufficiently rapid, the metal dissolution that occurs at the film fracture site could lead to crack initiation.

In studying repassivation, the film should be removed in such a way that the surface produced simulates that found under naturally occurring conditions of film rupture. Also, a reflecting metal surface, necessary for ellipsometry, must be produced during film removal. These factors led to the use of a rotating wheel incorporating a fine abrasive that removes the film while still preserving a surface finish sufficiently reflective for the ellipsometer to measure the formation of films less than 10 Å (or 1×10^{-9} m) thick.

In ellipsometry, a beam of elliptically polarized light is reflected from a surface in such a way that the change in ellipticity of the light resulting from reflection can be measured. These measurements are related to the optical properties of surfaces and to the thickness and refractive index of any films on them.

Because the initial phase of repassivation generally takes place within 50 ms of film removal, the polishing wheel must be withdrawn from the specimen surface and from the path of the ellipsometer light beam at high speed. To accomplish this, two fast-rise-time solenoids move the abrasion wheel and allow measurements of growth kinetics within 10 ms of cessation of abrasion.

As an example of the utility of tribo-ellipsometry in observing repassivation kinetics, studies were made on the relationships between the rate of repassivation and stress corrosion susceptibility of a mild steel in a sodium nitrate solution and of a titanium alloy in a sodium chloride solution, environments known to produce cracking. The steel was also observed in sodium

Dr. John Ambrose makes ellipsometer measurements of the oxide film thickness on a titanium alloy.
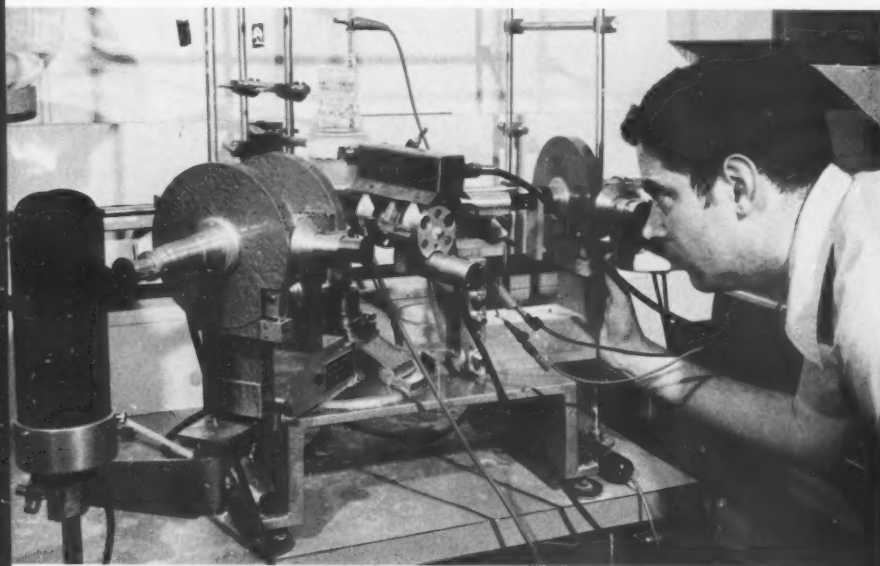
nitrite and sodium chloride solutions and the titanium alloy in a sodium nitrate solution.

In solutions known to cause stress corrosion cracking, the rates of film growth were shown to be slower than those observed in the solutions where stress corrosion cracking is not known to occur.

Such low rates of film regrowth led to increased metal dissolution rates for the stress corrosion susceptible systems. When test results were expressed as a ratio of total current to film thickness, a parameter was provided which would characterize the corrosion process. When the ratio is low, effective repassivation is indicated; a high ratio correlates with pitting and metal dissolution; and an intermediate number indicates the possibility of stress corrosion cracking.

[1] Ambrose, J. R., and Kruger, J., Tribo-ellipsometry: a new technique to study the relationship of repassivation kinetics to stress corrosion, Corrosion-NACE 28, 30-34 (1972).

Standard Reference Material for Analyzing Lead-Based Paints Available

A new standard reference material has been formulated to aid health authorities in protecting children from lead paint poisoning.

An estimated 600,000 American children between the ages of 1 and 6, mostly in the inner cities, are victims of lead poisoning caused by eating paint chips from old walls or by gnawing on window sills and door frames. Short of death, one of the worst consequences of lead poisoning is mental retardation. Unfortunately, the early symptoms of lead poisoning—headache, irritability, vomiting, and anemia—are too much like other less serious childhood complaints to command proper attention.

Many municipalities are now surveying older homes for the presence of paint containing more than 1 percent lead by weight. To aid these groups in analyzing paint scrapings, NBS chemists have prepared a powdered, lead-based-paint Standard Reference Material (SRM 1579).[1,2] The SRM can be used to calibrate the apparatus and methods utilized in making lead-in-paint determinations. Because legal action can result from these measurements, the ability to make reliable, repeatable determinations is essential.

The major danger of lead poisoning arises from paints manufactured at least 30 years ago. Most manufacturers no longer add lead to their paints. However, to ensure that paints of a high lead content are not sold, the Food and Drug Administration banned, as of January 1, 1973, the use of paints containing more than 0.5 percent lead by weight on residential surfaces accessible to children.

SRM 1579 is representative of the powdered mixtures of paint scrapings obtained from old dwellings. The raw material for this SRM was collected by the staff of the Philadelphia Department of Public Health from interior walls and woodwork of old houses undergoing renovation in that area. At NBS, in work sponsored by the Department of Housing and Urban Development, the foreign substances were separated from the paint scrapings, which were then ground, milled, and blended to a powder that passes a 325-mesh sieve.

This material is considered to be more typical of old, dried-out, intractable paints collected in the field than freshly prepared paint formulations containing precisely measured amounts of lead as a single pigment or a mixture of pigments. For example, the lead-based pigments in fresh paint are easily soluble in acids or ammonium acetate solutions and can be analyzed by many methods. On the other hand, dried aged paints may give erroneous results due to the difficulty of extracting the lead from the paint matrix. Dried paint chips collected from old housing had the desired property of stability (they were already 30-50 years old); they were truly representative of material gathered in the field; and, with careful preparation, they could be made homogeneous.

Sample homogeneity of the powdered paint was evaluated using x-ray fluorescence to analyze the lead content of randomly selected samples. The lead content of the SRM was certified at 11.87 ± 0.04 weight percent using atomic absorption spectrometry and differential cathode-ray polarography. As a further check on the lead content, the powdered, lead-based paint was analyzed by electrolytic deposition and by nuclear activation analysis.

The analytical procedures involved dry ashing in a furnace at 450-550 °C followed by exhaustive extractions of the insoluble residue with acids and ammonium acetate solution. Included in the SRM certificate is a procedure for completely extracting lead from the paint matrix. After this has been accomplished, any proven analytical method can be used for the lead determination.

[1] SRM 1579 may be purchased in 35-gram units for $35 from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234.

[2] Greifer, B., Maienthal, E. J., Rains, T. C., and Rasberry, S. D., Development of NBS Standard Reference Material 1579, Powdered Lead-Based Paint, NBS Spec. Publ. 260-45 (in press). Will be available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

TV TIME
PETITION SENT TO FCC

The Secretary of Commerce has petitioned the Federal Communications Commission to change the television broadcasting rules to permit sending time, frequency, and other information over the nation's TV networks.

The petition, in behalf of NBS, was sent to the FCC Commissioners on December 22.

It would allow the newtorks to broadcast encoded information on one line of the blanking interval (the black line between TV images seen when the picture rolls.)

"Only viewers with special equipment on their television sets would receive the information broadcast by the networks with National Bu-'reau of Standards supervision," Secretary Peterson said. "This broadcast signal, called NBS Tv-Time, in no way interrupts or affects the quality of the normal TV picture."

The TvTime system, developed by scientists and engineers at the NBS Boulder, Colo., laboratories,

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Correction: There is an error in the metric chart that appeared in last month's Technical News Bulletin. Under temperature, the statement should read "The Fahrenheit degree is an interval of $\frac{5}{9}$ °C or $\frac{5}{9}$ K."

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generates a signal which can be carried on one line of the blanking interval during broadcast. Special electronic equipment at the broadcast station and complementary equipment on the television set allow information to be encoded and decoded to provide useful information in caption form on the television screen. Only specially equipped sets can decode the signal. Viewers with normal sets will not see the captions. Time-of-day information can be broadcast to one millionth of a second accuracy.

NBS developed the system to provide accurate information to the thousands of commercial and scientific institutions which require precise time and frequency—among these, aviators and navigators, the power industry, and the broadcast networks themselves.

In addition to time and frequency, the signals will provide a means of captioning television programs for the deaf or for foreign-speaking audiences. Channel identification, weather and disaster information, and other important information could also be transmitted by the NBS TvTime system. The signals can be used to automatically reset electric clocks after a power failure, and can help analyze power failures on a continent-wide basis. They can be used to accurately determine position on the earth and are useful for many computer and business operations.

The primary standard of frequency and time is the NBS Atomic Clock System maintained at

Boulder. Presently these standards are disseminated to users via radio broadcast (which are inexpensive but less accurate) and by portable atomic clocks (highly accurate but costly). The TvTime System will provide high accuracy at relatively low cost to the user.

The Bureau will supply the major public and private networks with the equipment needed to originate timing signals. Local stations will have the option of passing the network signals on to users, or originating TvTime signals themselves under FCC and NBS supervision. Users of the system will need special decoders built into or added onto their receivers. The cost depends on the features desired; that is, time signals, captions, channel identification, etc.

As provided by the TV station, hour-minute-second time of day information, channel identification and captions would be displayed as small numbers and letters on the TV screen. The time display is accurate to a few thousandths of a second. Time-of-day information accurate to one millionth of a second would be available with an optional high-accuracy decoder. A frequency reference at 1 MHz, accurate to one part in 100 billion, is also available at the receiver.

The TvTimer System can transmit up to 600 words per minute, which is more than that required for captions. The excess capacity will be available for other purposes, such as communications between network and affiliate.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Annual subscription: Domestic, $6.50; foreign, $8.25 Single copy price, 65 cents. Available on a 1-, 2-, or 3-year subscription basis. SD Catalog No. C13.13.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $17.00; foreign, $21.25. Single copy price varies. SD Catalog No. C13.22/sec.A.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $9; foreign, $11.25. Single copy, $1.25. SD Catalog No. C13.22/sec.B.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.C.

NBS BIBLIOGRAPHIC SUBSCRIPTION SERVICES

Cryogenic Data Center Current Awareness Service (Publications and Reports of Interest in Cryogenics). A literature survey issued weekly. Annual subscription: Domestic, $20.00; foreign, $25.00.

Liquefied Natural Gas. A literature survey issued quarterly. Annual subscription: $20.00.

Superconducting Devices and Materials. A literature survey issued quarterly. Annual subscription: $20.00. Send subscription orders and remittances for the preceding bibliographic services to the U.S. Department of Commerce, National Technical Information Service, Springfield, Va. 22151.

Electromagnetic Metrology Current Awareness Service (Abstracts of Selected Articles on Measurement Techniques and Standards of Electromagnetic Quantities from D-C to Millimeter-Wave Frequencies). Issued monthly. Annual subscription: $100.00 (Special rates for multi-subscriptions). Send subscription order and remittance to the Electromagnetic Metrology Information Center, Electromagnetics Division, National Bureau of Standards, Boulder, Colo. 80302.

OTHER NBS PUBLICATIONS

TN361. (Revised October 1972). **Liquid densities of oxygen, nitrogen, argon,**
and parahydrogen, H. M. Roder, R. D. McCarty, and V. J. Johnson, Nat. Bur. Stand. (U.S.), Tech. Note 361 (Revised), 181 pages (Oct. 1972) $1.25, SD Catalog No. C13.46:361 (Revised).

TN625. **Computer programs for thermodynamic and transport properties of hydrogen (Tabcode-II),** H. M. Roder, R. D. McCarty, and W. J. Hall, Nat. Bur. Stand. (U.S.), Tech. Note 625, 226 pages (Oct. 1972) $1.75, SD Catalog No. 13.46:625.

TN626. **The generation of an accurate and uniform time scale with calibrations and prediction,** K. Yoshimura, Nat. Bur. Stand. (U.S.), Tech. Note 626, 64 pages (Nov. 1972) 60 cents, SD Catalog No. C13.46:626.

TN631. **Thermophysical properties of helium-4 from 2 to 1500 K with pressures to 1000 atmospheres,** R. D. McCarty, Nat. Bur. Stand. (U.S.), Tech. Note 631, 161 pages (Nov. 1972) $1.25, SD Catalog No. C13.46:631.

TN710-6. **Building research translation: Ventilation air inlets for dwellings,** M. Croiset and H. Bizebard, Nat. Bur. Stand. (U.S.), Tech. Note 710-6, 62 pages (Jan. 1973) $1.00, SD Catalog No. C13.46:710-6.

PUBLICATIONS IN OTHER JOURNALS

This column lists all outside publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time. The five-digit number at the beginning of each entry is used for record keeping only and should not be used when requesting reprints or other information.

13050. Branscomb, L. M., **To help advance our Nation's scientific and technical capability for the greatest public benefit,** *Mater. Res. Stand.* 12, No. 5, 8-12 (May 1972).

13051. Kushner, L. M., **We have decided to become more active at the policy level in voluntary standardization activities,** *Mater. Res. Stand.* 12, No. 5, 13-14 (May 1972).

13052. Andrus, W. E., **A focus for the Bureau and all voluntary standardization organizations,** *Mater. Res. Stand.* 12, No. 5, 15-17 (May 1972).

13053. Ambler, E., **A major innovation is our measurement assurance program,** *Mater. Res. Stand.* 12, No. 5, 18-23 (1972).

13054. Hoffman, J. D., **IMR emphasizes accurate measurements and standards for materials,** *Mater. Res. Stand.* 12, No. 5, 24-33, 71 (May 1972).

13055. Willenbrock, F. K., **We can never afford to be technically wrong,** *Mater. Res. Stand.* 12, No. 5, 34-36, 71-72 (May 1972).

13056. Young, T. R., **Laboratory evaluation: Facing up to a national problem,** *Mat. Res. Stand.* 12, No. 11, 22-26 (Nov. 1972).

13057. Rowland, G. A., **A program to assist the States in accepting industrialized housing,** *Mat. Res. Stand.* 12, No. 11, 17-21 (Nov. 1972).

13058. Powell, C. J., Mandl, A., **High-resolution measurements of the $L_3M_{2,3}M_{4,5}$ Auger transitions in nickel and copper,** *Phys. Rev. Lett.* 29, No. 17, 1153-1156 (Oct. 23, 1972).

13059. Sengers, J. M. H. L., Greer, S. C., **Thermodynamic anomalies near the critical point of steam,** *Int. J. Heat Mass Transfer* 15, 1865-1886 (1972).

13060. Acquista, N., Abramowitz, S., **Infrared spectrum of matrix isolated NbF_5,** *J. Chem. Phys.* 56, No. 11, 5221-5224 (June 1, 1972).

13061. Wall, L. A., Brown, D. W., **High pressure polymerization of perfluorostyrene,** *J. Fluorine Chem.* 2, No. 1, 73-85 (1972/73).

13062. Barnes, J. A., Winkler, G. M. R., **The standards of time and frequency in the U.S.A.,** *Proc. 26th Annual Symp. on Frequency Control, Atlantic City, N.J., June 6-8, 1972,* pp. 269-284 (Electronic Industries Association, Washington, D.C., 1972).

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76